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THE USE OF PLANS AND ELEVATIONS IN THE STUDY OF GEOMETRICAL CRYSTALLOGRAPHY[1]

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With Drawings by P. I. Aguerrevere and S. E. Aguerrevere

In making crystal drawings it is customary to use clinographic or oblique projections. These drawings are probably the most satisfactory for descriptive purposes in articles and text-books, for they give the appearance of solidity. Clinographic projections, however, are rather difficult to draw and take too much of the student's time to be used in elementary class work. Yet it seems advisable for the student to employ some form of crystal drawing in order that he may gain an adequate idea of the geometry of crystals.

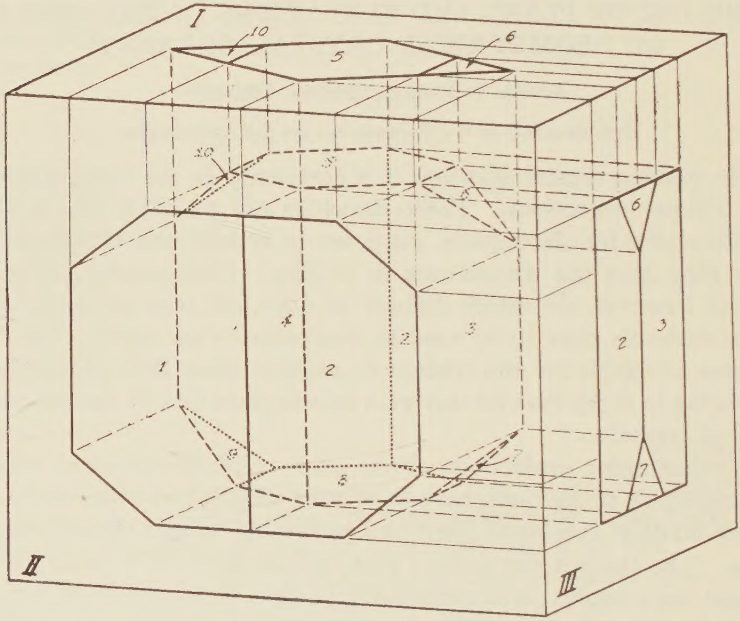
Orthographic projections, either plans or plans combined with clinographic projections, have been used widely, but little use has been made of combined plans and elevations, simple though they are. The student can make a plan and an elevation of a crystal, if not too complex, in a comparatively short time, and from these two drawings it is possible to determine graphically the axial elements of the crystal and the Miller indices of the forms. The method is simple and direct as compared with other methods such as the stereographic or gnomonic projections which of course are to be preferred for advanced work.

The writer has found that graphic methods based upon plans and elevations furnish the best solution of the rather difficult problem of teaching geometrical crystallography to students in elementary mineralogy. Measurements of typical crystals from 2 to 6 cm. or so in size are made with the contact goniometer, and from these measurements the plan and one or more elevations are

[1]Paper presented at the annual meeting of the Mineralogical Society of America, Amherst, Mass., Dec. 29, 1921.

constructed. An advantage of the contact goniometer over the reflection goniometer is that measurements are possible between edges as well as faces.

In constructing plans and elevations it is necessary, or at least advisable, to employ the methods of descriptive geometry. The third angle or quadrant is used so that the plan appears above the elevation instead of below it as in the first angle projection.[2]



S.E.A. del.

FIGURE 1. STEREOGRAM SHOWING CLINOGRAPHIC PROJECTION OF AN ORTHORHOMBIC CRYSTAL AND ORTHOGRAPHIC PROJECTIONS ON THREE AXIAL PLANES I, II, AND III.

If more than one elevation is drawn, the seventh octant is used. This is illustrated in Fig. 1, which is a stereogram of an orthorhombic crystal and its orthographic projections on the three axial planes I, II, and III drawn in clinographic projection. The

[2]A good argument for this method is found in the drawing of hemimorphic crystals such as tourmaline in which case the plan of the upper end of the crystal will appear above the elevation and the plan of the lower part below the elevation.

method of producing the plan and elevations is shown in this stereogram. Lines (fine dotted) are drawn from the vertices of the crystal normal to the axial planes and thus the three orthographic projections are produced. These three projections are connected each with each as shown by fine solid lines.

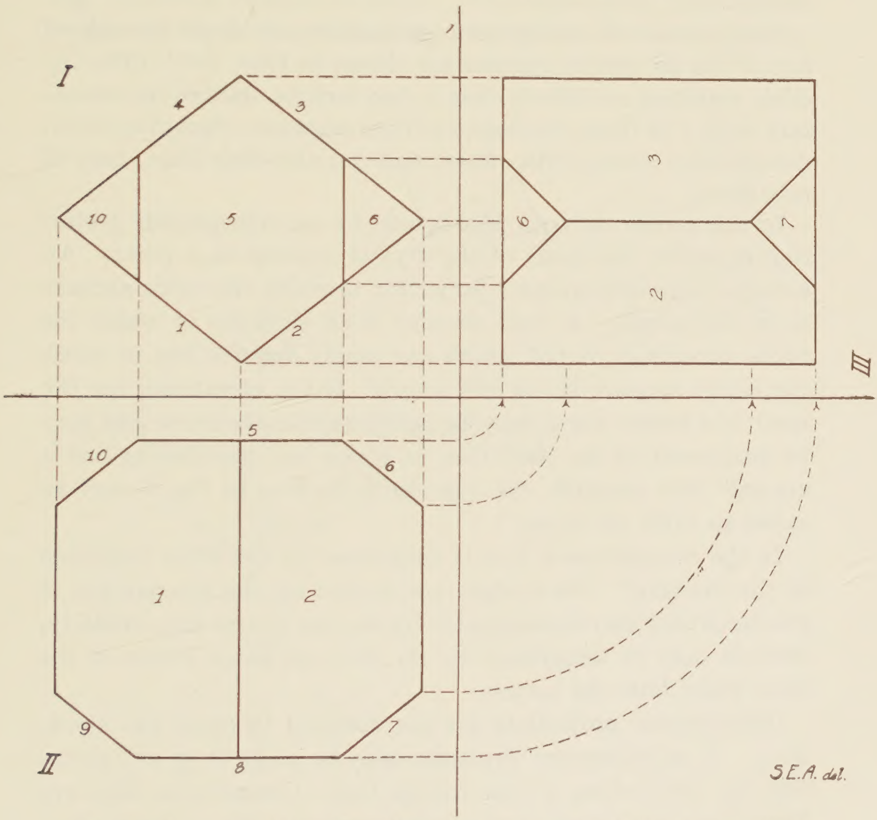


FIGURE 2. PLAN (I), FRONT ELEVATION (II), AND SIDE ELEVATION (III) OF THE ORTHORHOMBIC CRYSTAL SHOWN IN FIGURE I.

Fig. 2 shows the plan, front elevation, and side elevation folded out as they appear in actual practice. The drawings are made by measuring and plotting interfacial angles. For example, the plan I is drawn from the interfacial angles 1:2, 2:3, 3:4, and 4:1. For the front elevation II, the interfacial angles 5:6, 5:10, 7:8, and 8:9 are necessary. The side elevation III is produced by the intersection of lines from the vertices of the plan with those from the front

elevation after swinging them through arcs of 90°. Corresponding vertices in each elevation are the same distances from the folding lines, which makes possible the construction of any number of elevations after one of them is drawn. The two elevations are as closely related to each other as the plan and elevations are.

Illustrations of orthographic projections of ideal[3] crystals of five of the six crystal systems are shown in Figs. 3–7.[4] (The triclinic system is so difficult that it may well be omitted in elementary work.) In these drawings, full lines represent edges of crystals; dotted lines, construction lines; and dot-and-dash lines, axes of reference.

In this article the term *plan* is used for an orthographic projection in which the *c*-axis of the crystal appears as a point. An *elevation* is an orthographic projection in which the *c*-axis appears in its full length. A *front elevation* is an elevation in which the *b*-axis appears in its full length and a *side elevation* one in which the *a*-axis appears in its full length. Other elevations, for the want of a better name, may be called *angular elevations* and may be designated by the (*hk0*) face to which the new folding line is normal.[5] For example, the right-hand drawing of Fig. 3 may be called an (110) elevation.

In the descriptions a face is designated by the letter indicated in the drawing.[6] Since edges are formed by the intersection of two faces they may be designated by the two letters and, similarly, vertices may be designated by the three or more letters of the faces which form the vertex.

Orthographic projections are not confined to plans and elevations. A *supplementary projection* may be made from any elevation by establishing a new folding line. Construction lines are drawn from the points of the elevation normal to the folding line. The vertices in the new drawing are the same distances from the

[3] In practice the various faces would be shown in their actual development.

[4] Other examples are given in the writer's *Introduction to the Study of Minerals and Rocks,* (pp. 97, 101, 111, 115, 120, and 123), 2nd edition, 1921.

[5] It is well in every case to have the folding line normal to a crystallographically possible face.

[6] The method of designating various faces of a form is the same as that given in Dana's *System of Mineralogy,* 6th edition, 1892.

new folding line as the vertices of the plan are from the original folding line. An example of a supplementary projection is shown in Fig. 4.

ORTHORHOMBIC SYSTEM.[7] The graphic determination of the axial elements and indices of an orthorhombic crystal is shown in Fig. 3, which represents topaz. The interrupted lines at the bottom of the two elevations represent traces of cleavage planes.

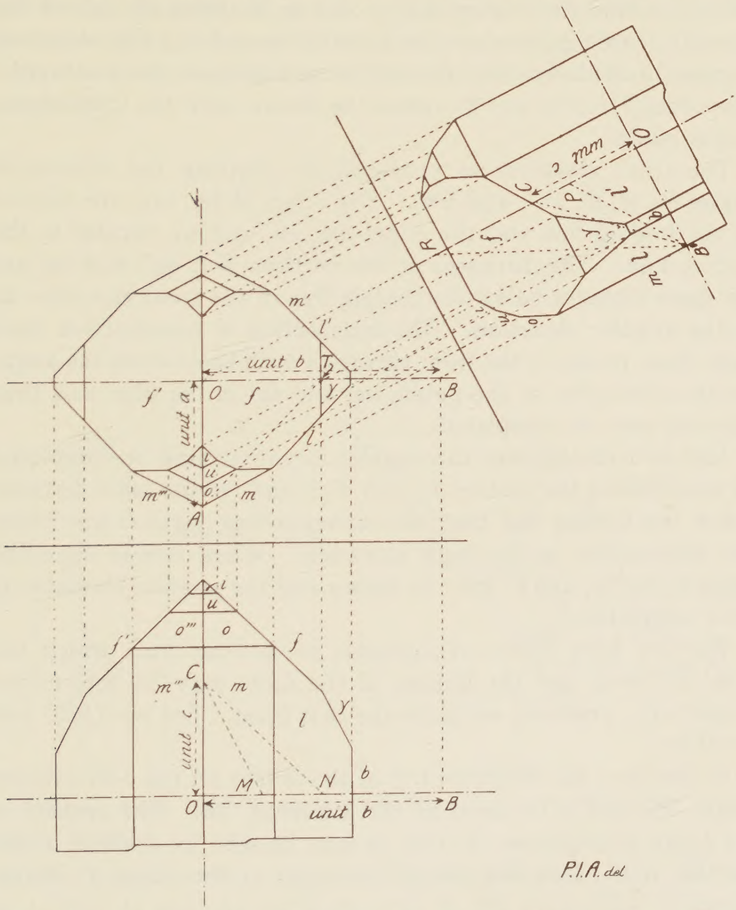


FIGURE 3. PLAN, FRONT ELEVATION AND ANGULAR ELEVATION OF A TOPAZ CRYSTAL.

[7] The writer in his crystallography class begins with the orthorhombic system. The triclinic system is too general and the isometric system too specialized to serve as a starting point.

The plan, or as much of it as is possible, is first drawn from the interfacial angles mm''', ml, lb, bl', $l'm'$, etc. The edge yf is parallel to the edge ff' and the edge fo is normal to the edge ff'. The edges ou and ui are parallel to the edge om, but the edges uf and if cannot be drawn until the elevations are made.

Next the angular elevation on the right is made on construction lines parallel to the edge om by plotting the interfacial angles mo, ou, ui, and the corresponding ones on the opposite side of the crystal. (An angular elevation is made instead of a side elevation because in the latter case no interfacial angles can be measured). The edges fl, ly, $l'y$, and fl', cannot be drawn until the front elevation is made.

The front elevation is produced by plotting the interfacial angles by, yf, ff', $f'y'$, and $y'b'$. The edges bl, lm, etc. are normal to the folding line and the edges om, ou, and ui, parallel to the folding line. The distances of the vertices omf, uof, and iuf are the same distance below the folding line in the front elevation as in the angular elevation. The intersection of construction lines from these points in the front elevation with those from the angular elevation give us the points uof and iuf in the plan and thus the plan may be completed.

And in a similar way the angular elevation may be completed by establishing the vertices lyf, lyb, $l'yb$, and fyl' the same distance below the folding line that the corresponding vertices are below the folding line in the front elevation. When this is done the edges lf, ly, $l'y$, and $l'f$ may be drawn and the angular elevation is thus completed.

We now have three orthographic projections from which the axial elements and the indices of the faces may be determined graphically, provided we know the unit faces. Let $m=(110)$ and $u=(111)$.

In the plan, the intercept OA of the m face on the a-axis determines the unit a in terms of the intercept OB. The symbol of the l face is $1a{:}\frac{1}{2}b{:}\infty c$ or (120) as may be seen by drawing a line parallel to l. This line meets the b-axis at the point T ($OT=\frac{1}{2}OB$).

In the angular (110) elevation a line drawn from the point B' parallel to the u (111) face cuts the c-axis at the point C. OC, then, equals the unit c in terms of OB (in the plan). Lines drawn from the point B' parallel to the projection of o and i cut the c-axis at

the points R and P, respectively. As $OR=2\ OC$ and $OP=\frac{2}{3}\ OC$, the symbols of o and i are $1a{:}1b{:}2c$ (221) and $1a{:}1b{:}\ \frac{2}{3}\ c$ (223), respectively.

The symbols of f and y are determined in the front elevation. The unit b and the unit c are transferred from the plan and the (110) elevation. From the point C on the c-axis lines are drawn parallel to the projection of the f and y faces. These intersect the b-axis at the points M and N, respectively. Since $ON=\frac{1}{2}\ OB$ and $OM=\frac{1}{4}\ OB$, the symbols of f and y are $\infty a{:}\frac{1}{2}\ b{:}1c$ (021) and $\infty a{:}\frac{1}{4}b{:}1c$ (041), respectively. The symbol of the b-face is $\infty a{:}1b{:}\infty c$ (010).

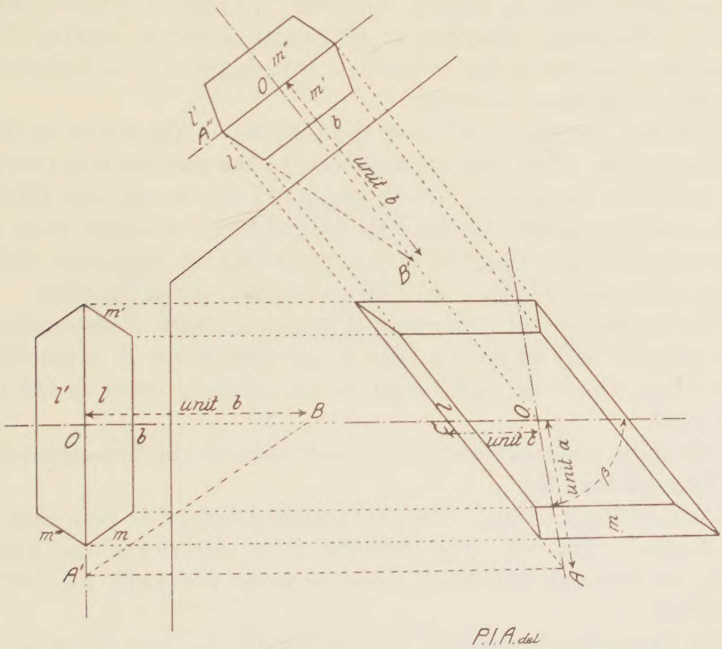


FIGURE 4. PLAN, SIDE ELEVATION, AND SUPPLEMENTARY PROJECTION OF A GYPSUM CRYSTAL.

MONOCLINIC SYSTEM. Gypsum with the forms m (110), b (010), and l (111) is selected as an example of the monoclinic system (Fig. 4). The problem is to determine the axial ratio $a{:}b{:}c$ and the angle beta (β).

First, the plan is drawn from the interfacial angles m''', bm, etc. A convenient distance OB is chosen for the unit length on the

b-axis. The projection of the *a*-axis lies at right angles to that of the *b*-axis but the distance OA' is the foreshortened unit on the *a*-axis.

The side elevation is drawn next and for this purpose it is necessary to measure the angles between the edges mm''' and ll' by means of a contact goniometer.[8]

In order to complete this elevation a supplementary projection must be used. This is made as shown in the drawing from the interfacial angles *bl* and ll'. The intersection of dotted lines drawn from the point *lmb* in the plan and in the supplementary projection furnishes the point *lmb* in the side elevation. The edges *lb* and *mb* are parallel to the edges ll' and mm''' and thus the side elevation is completed. There is no particular object in making the front elevation for in the monoclinic system there is no zone-axis normal to the front elevation.

It is first necessary to locate the position of the *a*-axis in the side elevation. The edge *ml* is parallel to the possible face (001), for the three faces (110), (111), and (001) are in the zone $[1\bar{1}0.]$ The *a*-axis is parallel to the edge *ml*, and if OA is drawn from a convenient origin O parallel to the projection of this edge, OA, then, is the unit length of a in terms of OB $(=b)$ of the plan.

The intersection of a line from A coincident with ll' determines the point C and since this edge is the projection of a possible (101) face, OC is the unit length of the *c*-axis in terms of OB of the plan.

The acute angle between the *a*- and *c*-axes in the side elevation is the angle beta (β).

Tetragonal System. For this system a crystal of vesuvianite is chosen. (Fig. 5.) The problem is to determine the axial ratio $a{:}c$ and the indices of t and s; given $p=(111)$, $a=(100)$, $c=(001)$.

The plan is first drawn ($am=45°$; $aa'=90°$); the edge *st* is parallel to ss^{vii} and pp''', and *pt* parallel to *mt*.

[8] In order to plot the crystal from interfacial angles alone, recourse may be had to a graphic method based upon the properties of polar triangles as has been suggested by my colleague, Professor L. E. Cutter of the Mechanical Engineering Department. The solution of this is given in Cutter's *Descriptive Geometry* now in press (McGraw-Hill Book Co., *New York*). But in the opinion of the writer, instead of using polar triangles, it would be preferable to make a stereographic projection. From a stereographic projection a side elevation may easily be constructed.

The angular (110) elevation on the right is made from the interfacial angles *cp*, *pt*, and *tm*. The elevation may be completed from the fact that *s′s‴* is parallel to *ts* and *ps′* parallel to *as′*.

The front elevation may be constructed in either of two ways: (1) by measurement of the angles between the face *a′* and edge *s′s″*,

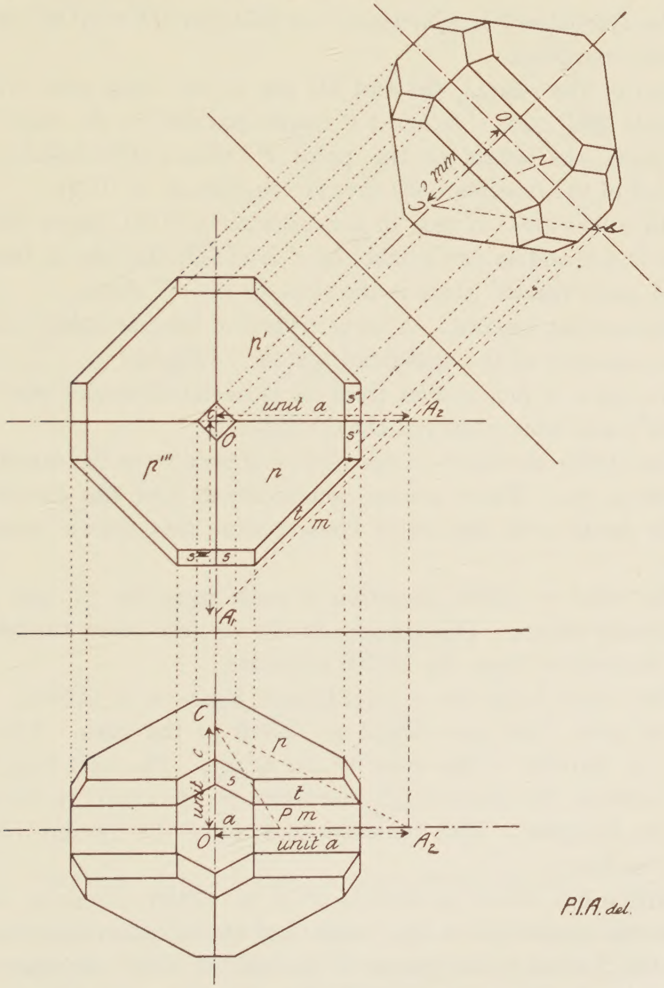


FIGURE 5. PLAN, FRONT ELEVATION AND ANGULAR ELEVATION OF A VESUVIANITE CRYSTAL.

edge *s′s″* and edge *pp′*, and edge *pp′* and face *c*, or (2) by the intersection of vertical lines from the plan with horizontal lines swung around from the angular elevation.

The side elevation is exactly like the front elevation, so it need not be drawn.

The unit c is the distance OC in the angular elevation in terms of OA_1 in the plan. (In the angular elevation this is foreshortened to OA'.)

The symbol of t is $\frac{1}{3}a_1:\frac{1}{3}a_2:1c$ or (331) for $ON=\frac{1}{3}OA'$ in the angular elevation.

Two of the s-faces, khl and $\bar{k}hl$ are in the same zone with a possible $(0kl)$ face. A line CP drawn parallel to the edge $s's''$ intersects the a-axis in the point P. Since $OP=\frac{1}{3}OA'_2$, the symbol of the possible $(0kl)$ face is $\infty a_1:\frac{1}{3}a_2:1c$ or (031).

The s-face (khl) is also in a zone with p (111), hence the $h:l$ ratio is 1:1 and so the symbol of s' is (131); the one in front is (311), since the ss''' slope is the same as the ss'' slope.

Hexagonal System. A beryl crystal of tabular habit is taken as an example of the hexagonal system. (Fig. 6.)

The plan is first drawn from the interfacial angles mm' etc. $(=60°)$ and from observed zonal relations.

The $(11\bar{2}0)$ elevation on the right is drawn from the interfacial angles cs, etc. There are no complications and the drawing is easily made with the aid of construction lines drawn from the plan.

The other or $(\bar{1}100)$ elevation is made from the cp^{v} and $p^{v}m^{v}$ interfacial angles. The distance of the vertices below the folding line is obtained from the $(11\bar{2}0)$ elevation.

The s-face is chosen as (1121) and hence m is $(10\bar{1}0)$. The lateral axes, then, are drawn as shown in the plan. The line $A''C$ is parallel to the trace of the s-face. The unit length on the c-axis is the distance OC (elevation on the right) in terms of OA_1 in the plan. This must be true, since the symbol of s is $1a_1:1a_2:-\frac{1}{2}a_3:c$.

Since a line drawn parallel to p^{v} in the $(\bar{1}100)$ elevation intersects the projection of the c-axis and the foreshortened lateral axis OA_1 at unity, the symbol of this face is $(1\bar{1}01)$ and that of p, which has the same slope, is $(10\bar{1}1)$.

Isometric System. For the isometric system a dodecahedral garnet crystal modified by a trapezohedron is selected. (Fig. 7.)

The first figure drawn is the plan, which is constructed from the interfacial angles dd' and the angle between d and the edge nn^{xii}.

The front elevation is next drawn and is exactly like the plan.

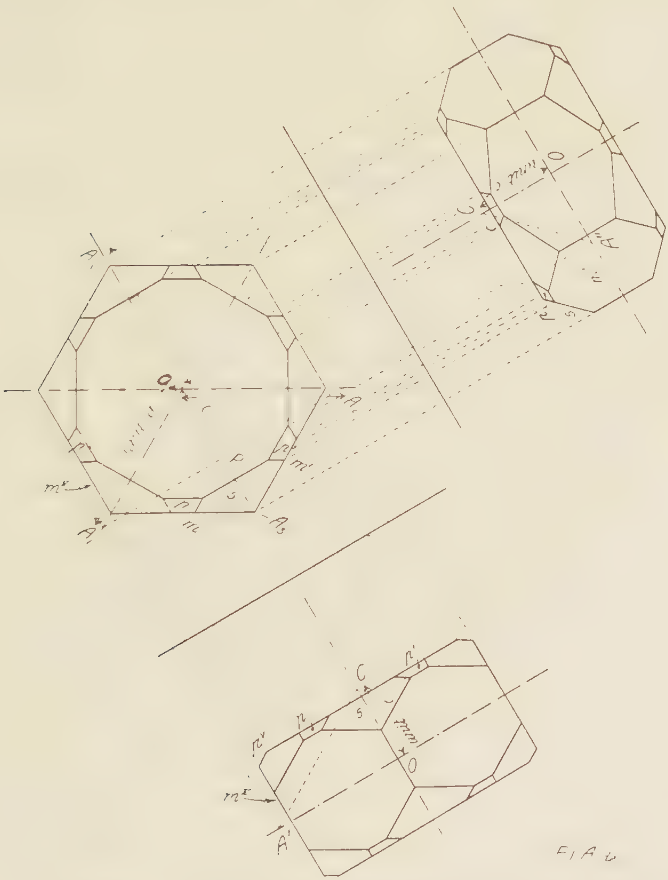


FIGURE 6. PLAN AND ELEVATIONS OF A BERYL CRYSTAL.

The angular (110) elevation is then constructed from the interfacial angles dn'' and $n''n^{viii}$. (It is drawn to the left to save space.) The vertical height of this elevation is the same as that of the front elevation.

The symbol of d is (110); the problem is to determine the symbol of the trapezohedron n, which is of the type (hkk).

In the plan, a line drawn parallel to the edge $hkk:hk\bar{k}$ from A_2 intersects the a-axis in the point R. Since $OR=\frac{1}{2}OA_1$, the ratio $h:k=2:1$ and so the symbol of n is (211).

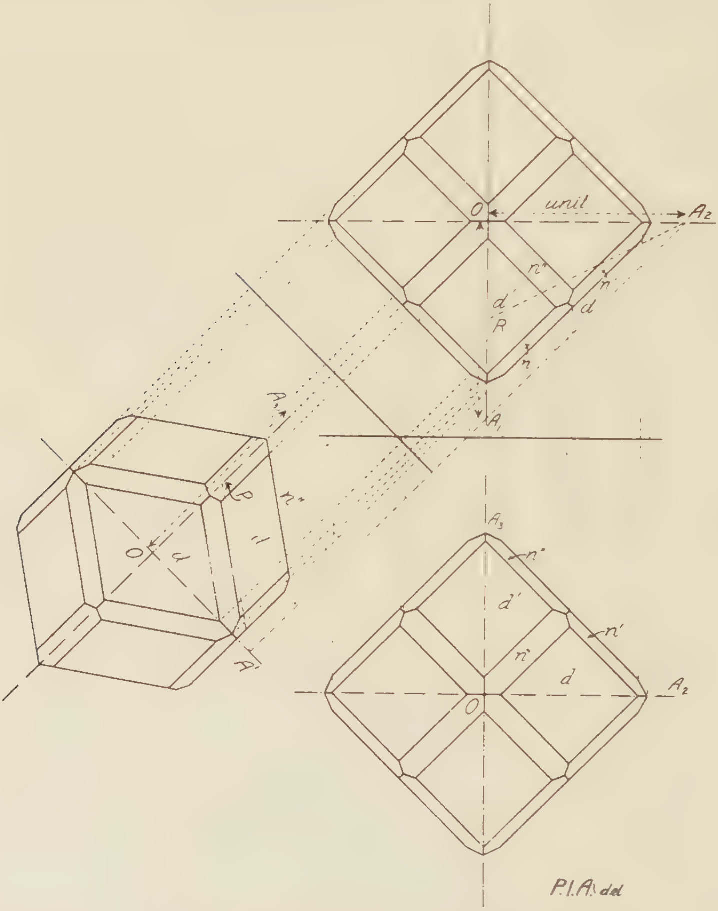


FIGURE 7. PLAN, FRONT ELEVATION, AND ANGULAR ELEVATION OF A GARNET CRYSTAL.

In the (110) elevation, a line drawn from A' parallel to the n''-face intersects the a-axis in the point P. $OP=\frac{1}{2}OA_3$ and so the ratio $k:h=1:2$ and $n''=(112)$.

SUMMARY AND CONCLUSIONS. Plans and elevations of simple crystals usually may be constructed from interfacial angles or from the angles between crystal edges in a comparatively short

time. The third angle projection (in some cases the seventh octant projection) is used and the methods of descriptive geometry are employed. The plans and elevations with an occasional supplementary projection furnish a convenient basis for the application of graphical methods. Miller indices, axial elements, and interfacial angles may be determined graphically and the student may also gain a good general idea of the symmetry and zonal relations of crystals.

PHOSGENITE FROM THE TERRIBLE MINE NEAR ILSE, CUSTER COUNTY, COLORADO

W. A. Waldschmidt, *Colorado School of Mines*

Recently the Colorado School of Mines received two samples of massive cerussite ore representative of the deposit at the Terrible mine near Ilse, Custer County, Colorado. The general appearance of these samples was that of massive crystalline cerussite, white to yellowish white in color, partially covered with a brownish yellow coating, and containing small vugs lined with druses of cerussite crystals. There were also inclusions in the samples which were darker in color and appeared to have different characteristics than the massive cerussite. Blowpipe tests were made on this dark mineral and the reactions obtained indicated immediately that it was not cerussite. Further tests showed the mineral to be the rare chlor-carbonate of lead, phosgenite, ($Pb\ CO_3.\ Pb\ Cl_2$). A preliminary quantitative analysis for lead, made by Professor W. V. Norris of the Department of Chemistry of the Colorado School of Mines, gave 75.3 per cent lead in the dark mineral, whereas the theoretical per cent of lead in phosgenite is 75.97. The color of the phosgenite from the Terrible mine is smoky transparent; luster, vitreous to adamantine; cleavage, perfect in three directions at 90 degrees; fracture, conchoidal; hardness, 2–3; streak, white; fusibility, 1–2; specific gravity (average of six determinations), 6.08. In addition to these physical properties good tests were obtained for lead, carbon dioxide and chlorine.

In preparing this article, in which is included a list of localities where phosgenite has been reported, it was found that the occurrence of phosgenite at the Terrible mine had already been men-

tioned by C. H. Warren in 1903.[1] Since that time, an article by R. B. Brinsmade,[2] describing the Terrible mine, appeared in the Engineering and Mining Journal Press, but the occurrence of phosgenite was not mentioned and apparently its occurrence was not known to the present owners of the mine. C. H. Warren has briefly described the phosgenite from the Terrible mine as follows: "Associated with the cerussite is the chlor-carbonate of lead, phosgenite. This is distinguished in appearance from the cerussite by its clear brown color and by three excellent cleavages, prismatic and basal, at right angles to each other. It was possible to identify the basal cleavage by the positive uniaxial interference figure obtained when sections parallel to this cleavage were examined under the microscope. On such fragments, a much poorer cleavage approximately half way between the prismatic cleavages was also observed, indicating the presence of the cleavage parallel to the face 100. The prismatic and basal cleavages are of about the same degree of perfection. In one specimen a somewhat tabular habit was noticed parallel to the basal cleavage.

"The relative amounts of cerussite and phosgenite vary considerably in different specimens, but the latter has always been observed as a core surrounding the former. In one specimen, weighing nearly two pounds, the cerussite is simply a rim averaging 1 cm. in thickness. This is separated from the phosgenite by a very narrow white band of powdery material. The above facts suggest that the cerussite is an alteration product of the phosgenite. Small cavities, possibly formed by solution, lined with acicular crystallizations of cerussite have been noticed in most of the specimens examined."

It may be of interest to note the peculiar features of the cerussite, observed by C. H. Warren, in which the phosgenite occurs.

Chemical Analysis of Cerussite from the Terrible Mine (Warren)

CO_2	17.02
FeO	trace
PbO	79.59
Alkali	trace
SrO	3.15
	99.76

[1] C. H. Warren, Mineralogical Notes, *Am. J. Sci.*, Series 4, **16**, 344, 1903.
[2] R. B. Brinsmade, *Eng. and Mining J. Press*, **83**, 844, 1907.

The cerussite is crystalline and massive in character, grayish white to light amber in color, and its surface covered with a yellowish brown coating.

From the above analysis and from specific gravities he concludes that this cerussite adds another "undoubted case of isomorphism to those already known among the orthorhombic carbonates."

According to R. B. Brinsmade, the Terrible mine was discovered in 1880 and had, up to that time, 1907, produced about 250,000 tons of ore. Some of the ore was smelted but most of it was oxidized directly to litharge which was exceptionally high grade. The main features of the deposit are: (1) a well marked fault plane on the east side with a dip of 67 degrees, filled with finely divided blue clay six to twelve inches thick; and (2) the confinement of the profitable ore to a block of granulite between walls of gneiss which has apparently been thrown into position by faulting. In the discussion of the genesis of the deposit he concludes that the ore is undoubtedly of secondary origin, states that no galena has ever been detected, but does not mention the occurrence of phosgenite.

Thus far, phosgenite has been reported from Matlock in Derbyshire, England; Cornwall, England; Elgin, Scotland; Gibbas, Monte Poni and Montevecchio in Sardinia; Bobrek in Upper Silesia; Broken Hills, New South Wales; Dundas, Tasmania; Laurium, Greece; and Ilse in Custer County, Colorado. Although phosgenite had already been reported from the Terrible mine, its presence was probably not known to many so that it was thought advisable to call attention again to its occurrence.

A CORRECTION: RECENTLY DESCRIBED CRYSTALS OF GLAUCOCHROITE FROM FRANKLIN, N. J., ARE TEPHROITE

SAMUEL G. GORDON, *Academy of Natural Sciences of Philadelphia*

In a recent article[1] on several Franklin, N. J. minerals, the writer described several interesting crystals as glaucochroite, with a number of new forms. Dr. Schaller has since suggested that the crystals are probably tephroite. The indices of refraction of

[1] Crystallographic notes on glaucochroite, willemite, celestite, and calcite, from Franklin, New Jersey: *Proc. Acad. Nat. Sci. Phila.*, LXXIV, 105–108, 1922.

some of the material were kindly determined, approximately, by Dr. Larsen to be as follows: $\alpha = 1.765 \pm .005$, $\beta = 1.78. \pm 01$, $\gamma = 1.79 \pm .01$, and an inspection of the following table will show the correspondence of these values with those of tephroite and the correctness of Dr. Schaller's identification.

REFRACTIVE INDICES OF TEPHROITE AND GLAUCOCHROITE FROM FRANKLIN, N. J.

	α	β	γ
Mineral in question	1.765 ± .005	1.78 ± 01	1.79 ± .01
Tephroite [1]	1.770	1.792	1.804
Tephroite [2]	1.759	1.786	1.797
Tephroite [3]	1.767	1.785	1.805
Glaucochroite [4]	1.686	1.722	1.735
Glaucochroite [5]	1.679	1.716	1.729

[1] Larsen, E. S., The Microscopic Determination of the Nonopaque Minerals, *U. S. Geol. Survey, Bull.* **679**, 143, 1921.

[2] *Ibid.* 270. Data for tephroite with 7.8 per cent of Mg_2SiO_4.

[3] Determined by Larsen on material similar to the described but from a different specimen (being studied by W. T. Schaller). Not hitherto published.

[4] Penfield's data.

[5] Determined by Larsen on Col. Roebling's specimen of original glaucochroite. Not hitherto published.

The change in identification necessitates a revision of the crystal forms described as new. Of these *r* (140), *d* (101), *k* (011), *l* (131) have already been described but the two forms (270) and (122) are new for tephroite. The letter *z*, assigned to (270) has already been given to (140); it is therefore changed to *j*. The letter *y*, assigned to (122) has been given to (150); it is therefore changed to *q*. In the table of forms and angles, given on p. 107, the following changes are therefore to be made. Star (as new forms) only *j* (270) and *q* (122). Omit *x* (103). Interchange the two letters *h* and *k* so as to read *h* (011) and *k* (021).

The writer is indebted to Dr. Schaller for the correct identification of the mineral, and to Dr. Larsen for the determination of the indices of refraction.

PROCEEDINGS OF SOCIETIES

NEW YORK MINERALOGICAL CLUB

Regular Monthly Meeting of November 8, 1922

The regular monthly meeting of the New York Mineralogical Club was held in the Assembly Room of the American Museum of Natural History on the evening of Wednesday, November 8th at 8:15 P.M. The President, Dr. George F. Kunz,

presided and there was an attendance of 19 members. The minutes of the last meeting were read and approved. On motion by the Secretary the following names were submitted to the Committee on Membership: Mr. J. S. Griggs, 64 West 8th Street, Whitestone, N. Y.; Mr. Charles Judson, 82 Beaver Street, New York City; Mr. Charles K. Cabeen, Dept. of Mineralogy, Columbia University.

Mr. Wintringham called attention to a paper by Pentti Eskola on "The Contact Phenomena between Gneiss and Limestone in Western Massachusetts." Dr. Kunz exhibited a photograph of the late Benjamin B. Chamberlin, a noted local collector, whose collection of New York City minerals constitutes the nucleus of the Club's present mineral collection.

Mr. Whitlock then delivered a short paper on "Field Tests for Recognizing the Crystal System of Minerals," in the course of which he emphasized symmetry as the essential key to identification of crystallized minerals in the field. Developing this line he outlined the symmetry of the seven systems and indicated many criteria for their recognition when crystals are only partly exposed to view. In the discussion of this paper Mr. F. I. Allen introduced the case of the cube as a limiting form of the rhombohedron, bringing up the relation of the Miller axial position in the rhombohedral system to the isometric. The meeting adjourned at 10:35 P. M.

HERBERT P. WHITLOCK, *Recording Secretary*

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, November 9, 1922

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the president, Mr. Vaux, in the chair. Twenty members and four visitors were present.

Upon the recommendation of the council, the following were elected to active membership: Messrs. Paul Wikul, John F. Deegan, Clarence F. Treston, and Ralph D. Pearse. Mr. Clay proposed Mr. Wilfred Broadwell for active membership.

Mr. Frank J. Keeley addressed the society on "Inclusions in Minerals." Inclusions of minerals, glass, liquids, and gases in a number of minerals were described including quartz, microcline, albite, oligoclase, garnet, muscovite, phlogopite, emerald, topaz, beryllonite, calcite, and corundum. By the aid of four microscopes illustrations of the following were exhibited: Brownian motion in inclusions of liquids in blue quartz from Bucks County, liquid and gas bubbles (CO_2) in topaz, films of quartz in muscovite, and chalcodite on byssolite from the calcite of French Creek.

Mr. Gordon presented briefly a paper on "Calciothomsonite, hodgkinsonite, leucophoenicite, and datolite from Franklin, N. J." A thomsonite in beautiful radiating masses associated with colorless barite showed on analysis a ratio of $CaO:Na_2O = 5:1$; with indices of refraction very much higher than those listed for this mineral. Druses of small reddish crystals on franklinite—willemite ore, alleged to be the recently announced, but not described, holdenite, proved on crystal measurement to be hodgkinsonite of unusual habit, with several new forms. Beautiful specimens of radiating masses of rhomboclasite from Peru were also exhibited.

Dr. Wills reported a trip to Moore Station, N. J. with Mr. Gordon, finding much stilbite. Mr. Boyle described an excursion to the French Creek mines, with Messrs. Clay, Jones, and Frankenfield. Very good apophyllite was obtained.

SAMUEL G. GORDON, *Secretary*

BOOK REVIEW

ELEMENTS OF OPTICAL MINERALOGY—AN INTRODUCTION TO MICROSCOPIC PETROGRAPHY. N. H. WINCHELL AND A. N. WINCHELL. Second Edition, Part I, Principles and Methods, entirely rewritten and much enlarged by A. N. Winchell. Octavo, XVI + 216 pages, with 250 text figures. John Wiley and Sons, *New York*, 1922.

Since the publication of the first edition in 1908, many important advances in optical mineralogy have been made, among which are the methods developed for the study of mineral powders and fragments, and small crystals immersed in liquids. In this edition the author has endeavored to present not only the material necessary for the study of minerals occurring in thin sections but also in powders and fragments and involving immersion in liquids. Much of the text has been used for several years in the Extension Division of the University of Wisconsin, and therefore is based upon actual experience with students.

The fundamentals of crystallography, as applied to the microscopic study of minerals, are discussed in two chapters. The physical and chemical characters are then taken up, followed by chapters on the Elementary Conceptions of Optics, Optical Properties of Isotropic Minerals, Microscopes, Preparation of Material for Microscopic Study, and the Nicol Prism. The optical properties of isotropic, uniaxial, and biaxial minerals are then treated in detail.

The book is well written, the style being clear and concise. The illustrations are numerous and well chosen. The directions for laboratory work found at the end of many of the chapters form an important feature of the book. The text should serve as an excellent introduction to the microscopic study of minerals.

EDWARD H. KRAUS

NEW MINERALS: DOUBTFUL SPECIES

CLASS: SULFIDES. DIVISION: R : S = 1 : 2.

"Corynite," "Kallilite," "Villamaninite"

E. THOMSON: A mineralographic study of the pyrite group. *Univ. Toronto Studies, Geol. Ser., No.* **12**, 32–39, 1921.

DISCUSSION: These alleged species are clearly shown by mineragraphic study to be mixtures, and should be removed from lists of minerals. E. T. W.

"Weibullite"

T. L. WALKER AND E. THOMSON: An examination of lillianite and galenobismutite. *Univ. Toronto Studies, Geol. Ser., No.* **12**, 11–15, 1921.

DISCUSSION: Material apparently identical with that described as "weibullite" is found by mineragraphic study to be a mixture of cosalite and guanajuatite, and the existence of this supposed species is at least doubtful. E. T. W.

CLASS: OXIDES. DIVISION: R:O = 1:1 (?)

"Trevorite"

ANDREW F. CROSSE: A rich nickel ore. *J. Chem. Met. Mining Soc. S. Africa*, **21**, 126, 1921.

NAME: After Major T. G. *Trevor*, Mining Inspector for the Pretoria District.

DESCRIPTION: An ore found near talc mines on the farm Bon Accord, north of the branch line to Barberton, near the Sheba siding shows on analysis NiO 40.30, FeO 49.30, SiO_2 6.50 and small amounts of other constituents. "This ore is, as far as I am able to judge, a new and undescribed mineral." Major Trevor describes it as a massive black rock composed of grains of magnetite with a slight green tinge.

DISCUSSION: This might be a mixture of bunsenite and magnetite, but requires mineralogical investigation. E. T. W.

CLASS: CARBONATES AND OTHER CARBON COMPOUNDS. DIVISION: HUMUS SUBSTANCES.

"Ulmite"

T. STEEL: Ulmite, a constituent of black sandstone. *Proc. Linnean Soc N. S. Wales*, **46**, 213–215, 1921; also in *Chem. News*, **123**, 293.

NAME: Evidently from the chemical term *ulmin*, which is in turn derived from the Latin *ulmus*, the elm tree.

CHEMICAL PROPERTIES: Formula, approximately $C_3H_4O_2$; theory C 50.0, H 5.6, O 44.4, sum 100.0%. Analysis gave, after deducting ash; C 50.53, H 5.67, O 43.20, N 0.60, sum 100.00%.

PHYSICAL PROPERTIES: A black film on sand grains, soluble in alkali.

DISCUSSION: No data are given to prove the homogeneity of this material, and it is questionable whether it should be considered a mineral at all.

E. T. W.

CLASS: PHOSPHATES, ETC. DIVISION: $RO:P_2O_5:H_2O = 6:1:7$.

"Arakawaite"

Y. WAKABAYASHI AND K. KOMADA. A phosphate of copper and zinc from the Arakawa mine. (In Japanese.) *J. Geol. Soc. Tokyo*, **28**, 191–211, 1921; through *Min. Abstr.* **1**, 250–251, 1922. (Abstract by R. O.)

NAME: After the locality, the *Arakawa* mine, near Akita, Japan.

CHEMICAL PROPERTIES: Formula, 6 (Cu, Zn) $O.P_2O_5 .7H_2O$ or $(Cu, Zn)_6 P_2O_{11} + 7H_2O$. (Theory, for Cu alone, CuO 64.0, P_2O_5 19.1, H_2O 16.9%). The mean of 3 analyses gave: CuO 40.44, ZnO 23.64, P_2O_5 19.01, H_2O 16.22, sum 99.31%.

CRYSTALLOGRAPHIC PROPERTIES: System monoclinic, with $a:b:c = 0.7497:1:1.0245$; $\beta = 70\frac{1}{2}°$. Forms (011), (110), $(\bar{1}11)$, $(\bar{1}21)$, $(\bar{3}11)$, $(\bar{5}26)$, $(\bar{5}24)$ and (100), the first two predominating.

Optical Properties: Biaxial, +; $\alpha=1.618$, $\beta=1.622$, $\gamma=1.658$. Optic axial plane (010); Bx_a making 36° with axis c in acute angle β; 2V = 38½°.

Physical Properties: Form, crystals up to 8×18 mm. Color, dark bluish green; luster, vitreous to resinous; translucent to opaque. H. = 3½; sp.gr. = 3.09.

Occurrence. In the oxidized zone of a copper lode.

Discussion. A similar mineral has been reported, without name, from Rhodesia: F. P. Mennell, *Min. Mag.*, **19**, 69–72, 1920. In both cases the materials differ from the most nearly related older species, veszelyite, in absence of arsenic, as well as in ratios. It may be noted also that veszelyite according to Larsen (*Micr. Detn. Non-op. Min.*) has somewhat higher refractive indices. Nevertheless the distinctness of the two can not be regarded as established. The ratios of neither are very definitely fixed, and the presence of a little isomorphous arsenic, making one mineral the arseniferous variety of the other, could raise the indices to the observed extent. For the present, "arakawaite" may be considered a sub-species of **veszelyite**. E. T. W.

CLASS: PHOSPHATES. DIVISION: R'': R''': P : H_2O = 1:2 : 2:1.

"Calcium lazulite"

T. L. Watson: Lazulite of Graves Mountain, Georgia, with notes on other occurrences in the U. S. *J. Wash. Acad. Sci.*, **11**, (16), 386–391, 1921; this mineral, p. 389.

Name: From the composition, a *calcium*-rich *lazulite*.

Chemical Properties: Formula, $4MgO.CaO.FeO.6Al_2O_3.6P_2O_5.6H_2O$, or $Mg_4CaFeAl_{12}(OH)_{12}(PO_4)_{12}$. Theory: MgO 8.6, CaO 3.0, FeO 3.9, Al_2O_3 32.9, P_2O_5 45.8, H_2O 5.8, sum 100.0%. Analysis by J. W. Watson gave (after deducting 6% SiO_2) MgO 9.64, CaO 3.30, FeO 4.24, Al_2O_3 36.02, P_2O_5 40.61, H_2O 6.19, sum 100.00%. The Al_2O_3 is abnormally high, the P_2O_5 low.

Physical Properties: Not essentially different from those of other lazulites; sp. gr. 2.958.

Discussion: To be classed as a variety of lazulite, perhaps most simply designated as **calciferous lazulite**. E. T. W.

CLASS: PHOSPHATES. DIVISION: Al:P:H_2O = 4:2:5 (?)

"Bolivarite"

L. Fernández Navarro and P. Castro Barea: La "bolivarita," nueva especie mineral. [Bolivarite, a new mineral species.] *Bol. soc. españ. hist. nat.*, **21**, 326–328, 1921.

Name: "Dedicated to the famous entomologist, D. Ignacio *Bolívar*."

Chemical Properties: Formula given as "$PO_4AlAl(OH)_3 + H_2O$". Spectroscopic examination showed the absence of other elements [altho fluorine is not noted as having been tested for]. An analysis is given, without mention of methods used and the results computed to 3 decimal places. [Since the usual methods of separating alumina and phosphoric acid are not capable of yielding results of significance beyond the unit place, only one additional figure for summation purposes is necessary.] The composition approximates: Al_2O_3 44.1, P_2O_5

34.9 and H_2O 20.6, sum 99.6%. [No data are given as to the temperature at which the water is evolved. It is evidently essentially identical with peganite].

PHYSICAL PROPERTIES: Color pale yellowish green, becoming white on exposure to the weather or upon heating. Luster vitreous. Structure, crusts with granular crystalline surface. Fracture splintery-conchoidal. H. = 2.5. Sp. gr. = 2.05. Under the microscope it shows a cryptocrystalline structure and weak birefringence. No optical constants could be determined.

OCCURRENCE: A pneumatolytic alteration product of granite, found near the road from Pontevedra to Campo-Lameiro.

DISCUSSION: Resembles turquois, but differs in the absence of copper. Should be classed as a **variety of peganite** until its distinctness is confirmed by further chemical and especially by optical study. E. T. W.

CLASS: SILICATES. DIVISION: R'': $SiO_2:H_2O = 1:1:X$.

"Katangite" = Cornuite, Rogers, 1917

H. BUTTGENBACH: Description of the minerals of Belgian Congo. *Mem. acad. royale Belg., Cl. Sci.*, [2], **6**, no. 8, 33 pages, 1921; this mineral, p. **26.**

NAME: From the locality, *Katanga.*

CHEMICAL PROPERTIES: A copper silicate, with the general ratios of dioptase, but giving about 10% water at 100° and 10% more at red heat. This is assumed to indicate the formula $H_2CuSiO_4 + Aq$. [Experience on colloid minerals has shown, however, that it is not sufficient to determine the water lost below and above 100°, and the only formula which can be regarded as at all established is $CuSiO_3 + X\ H_2O$. ABSTR.]

PHYSICAL PROPERTIES: Amorphous. Color bluish; adheres to the tongue; sectile; sp. gr. 2.4.

DISCUSSION: Evidently the same as amorphous chrysocolla, named **cornuite** by Rogers (Rev. amorph. min.; abstr. in *Am. Min.*, **3**, 157–158, 1918.).

E. T. W.

ABSTRACTS—CRYSTALLOGRAPHY

ESSENTIALS OF THE MINUTE STRUCTURE OF CRYSTALS. F. RINNE. *Physik. Z.*, **21**, 609–13, 1920.

Leptonology (λεπτός = fine, delicate) is the name proposed to designate stereochemistry, stereophysics and crystal structure as a group. The units dealt with (atoms, ions, molecules and even electrons) are called leptons. Geometrical crystallography may be regarded as macro-stereochemistry, crystals being sections of the leptonic structure whose faces and edges are planes and lines of high atomic concentration. In a leptonic sense amorphous matter is no less regular than crystalline, the latter representing three dimensional periodicity of space lattices, while the former may be compared with an excessively fine crystal powder. Leptonic structures may contain groups or clusters. These should be searched for and a means found to designate them, just as the chemist designates radicles in his chemical formulae. Mixed crystals are transitions between chemical compounds and physical mixtures and this conception may be extended to regular inter-

growths of unlike crystalline substances. Morphotropism is produced by chemical substitution which may slightly change the mode of aggregation of the leptons. R. suggests that certain structure types (isotypes) combine to produce form groups irrespective of the chemical composition. Crystal growth and solution is a matter of electrostatic attraction and repulsion between atoms in the outer layer of the crystal and the atoms in the solution. The leptonic structure of the crystal also plays a rôle in chemical decomposition, as shown by the alterations of the micas and zeolites. OTTO VON SCHLICHTEN

A SLIT-ULTRAMICROSCOPIC ARRANGEMENT FOR INVESTIGATING CRYSTALLIZED SUBSTANCES. WILHELM EITEL. *Centr. Min. Geol.*, **1919**, 74–85.

A description of the apparatus is followed by examples of certain minerals in whose investigation it was used. E. F. H.

UNMIXING DISPERSOIDS IN ANISOTROPIC MEDIA. WILHELM EITEL. *Centr. Min. Geol.*, **1919**, 173–183.

An investigation of mixed crystals of the system KCl-NaCl. E. F. H.

CERTAIN CENTRAL SECTIONS OF THE GLIDING ELLIPSOIDS OF CALCITE AND RUTILE. LEONHARD WEBER. *Centr. Min. Geol.* **1919**, 353–358.

A discussion of the relations of the crystal axes to the axes of the ellipses cut from the gliding ellipsoid by certain crystal faces. E. F. H.

WIRE SHAPED CRYSTALS OF TUNGSTEN. R. GROSS AND N. BLASSMANN. *Neues Jahrb. Min. Geol., Beil.-Bd.* **42**, 728–53, 1919; through *Min. Abst.* **1**, 187, 1921.

Electric light filaments after long use developed corrosion surfaces. On examining the wires by a modified Laue method, they were found to have become crystalline, with a somewhat distorted holohedral-cubic symmetry. E. F. H.

THE SIMPLE LATTICE FORMS OR EQUIVALENT LATTICE COMPLEXES. P. NIGGLI. *Centr. Min. Geol.*, **1919**, 38–43.

This paper gives a system of notation for simple lattice forms for use in determining by means of the X-rays which groups of movements such an "einfache Gitterform" may belong to. E. F. H.

AN ANALYTIC-GEOMETRIC INVESTIGATION OF CUBIC SPACE LATTICES. P. NIGGLI. *Neues Jahrb. Min. Geol., Beil.-Bd.* **43**, 1–73, 1919; through *Min. Abstr.*, **1**, 218, 1921.

The assignment of a cubic lattice form to its proper group of movements is investigated. E. F. H.

THE RULES OF TSCHERMAK AND BUYS-BALLOT. F. ZAMBONINI. *Atti. R. Accad. Sci., fis. mat. Napoli*, **16**, (14), 38 pp., 1916; through *Mineralog. Abstr.*, **1**, 367.

These rules attempted to show a relationship between the number or volume and form of the atoms in a compound and its crystal symmetry. They are tested by tabulating a large number of inorganic compounds. The conclusion is reached that no general relationship exists. E. F. H.